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FACTS ABOUT TRICHINOSIS

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Trichinosis, a disease caused by small threadlike parasitic worms called trichinae (Trichinella spiralis), is not catching. People get trichinosis when they eat raw or undercooked pork that contains trichinae. Few of the millions of hogs killed each year for food have living trichinae in their muscles. Because there are some trichinae, you should always eat pork that is thoroughly cooked. Cooking pork thoroughly kills the parasite and makes the meat safe for human consumption.

This pamphlet on trichinosis is designed as a reference or guide for agricultural leaders. Its purpose is to furnish you with background information on trichinosis. It is hoped the information will be helpful in answering questions hog producers may ask, in informing farmers and consumers about trichinosis, and as a reference in preparing news releases.

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Additional information may be obtained from the Animal Health Programs, Veterinary Services, Animal and Plant Health Inspection Service, U.S. Department of Agriculture, Federal Center Building, Hyattsville, Md., 20782.

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FACTS ABOUT TRICHINOSIS

For over a century, the knowledge that eating raw or insufficiently cooked pork could cause trichinosis has placed a stigma on pork.

Even before the discovery of Trichinosis, this stigma evidently existed in an undefined form. In Biblical times, pigs were referred to as "unclean" animals. The fundamental dietary laws of the Jews and the Moslems--which prohibit the eating of pork--may well have originated as a method of preventing this disease.

WHAT TRICHINOSIS IS . . .

Trichinosis is an excruciatingly painful disease that is among the most dreaded of human afflictions. It can result in death when infection is heavy--although less than 2 percent of all reported cases are fatal.

This disease is caused by very tiny parasitic worms called trichinae (Trichinella spiralis). It is not catching. People get trichinosis when they eat raw or undercooked meat that contains trichinae.

The threadlike worms spend most of their lives curled up inside a protective capsule or cyst in muscle tissue. When the meat is eaten, the digestive juices in the stomach free these encysted worms or larvae from their capsules. They then pass into the small intestine where they develop into mature males and females in about 2 days. After mating, the females give birth to large numbers of young (called larvae), starting about the sixth day after infection. One female will give birth to between 1,000 and 1,500 larvae.

These microscopic young worms penetrate the lining of the intestines, pass into the lymphatic system or the blood, and are carried to the heart. From there they are carried throughout the body by the circulating blood. They have an attraction for muscular tissue, so they invade the striated (voluntary) muscles of the body. They grow there for about 3 weeks, then coil up tightly, and in about 30 days develop a protective capsule--to complete the cycle. (Fig. 1.)

The worms can remain in this encysted form for many years--ready to infect any mammal that might eat the muscle tissue.

Trichinae are about 1/250 of an inch long when they are born. When they reach the muscle tissue, they grow to a length of 1/25 inch, coiling up in a cyst about 1/50 inch long. When they develop into adult males and females in the intestine, they are about 1/8 and 1/6 inch long, respectively.

HUMAN SYMPTOMS

The disease caused by trichinae occurs during the time the larvae are being produced and encysting in the muscle tissue. In many light infections, the host is never aware of the condition. However, once infection is established, evidence of this infection--in the form of the encysted larvae--will persist until the muscle tissue is destroyed.

The number of live trichinae in the meat that is eaten usually determines the seriousness of the disease. Eating moderate amounts of lightly infected raw or imperfectly cooked meat may

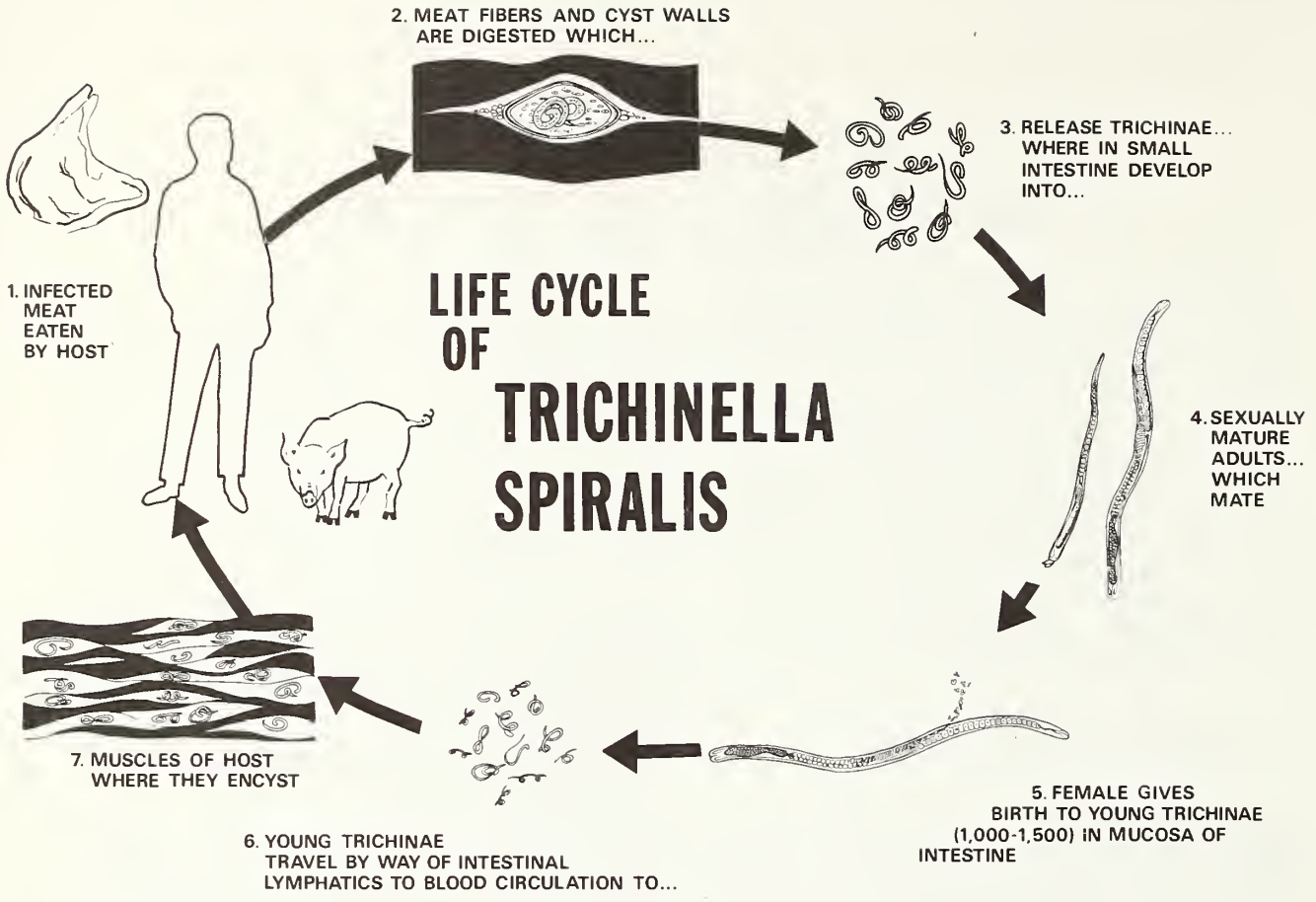

Figure 1.--Life cycle of the trichinae.

produce no illness or only slight illness. But eating even small quantities of undercooked or raw meat that contains large numbers of trichinae may produce a painful and serious case of trichinosis.

If the initial infection is relatively heavy, a person may have an upset stomach, vomiting, diarrhea, and other symptoms within 24 to 48 hours. However, these symptoms are often absent.

The symptoms characteristically associated with trichinosis occur during the period of migration and encystment. This starts about a week after infection and may continue for a month or more. When thousands of young trichinae travel through the body at one time, the person may have muscular pain, rising fever, headache, and prostration. When the larvae reach the muscles, other symptoms develop. These include swelling of the face and other parts of the body, sore eyes, hemorrhages under the skin, sore throat, headache, fever, and difficult breathing. Stiffness of the muscles may occur in severe infections. Some patients may have symptoms of heart disease or symptoms of brain disorder, such as delirium or coma.

SIGNS IN SWINE

Pigs usually tolerate this parasite quite well. Although signs similar to the symptoms seen in humans have been produced experimentally, they are seldom, if ever, seen in natural infections.

Thus, trichinosis is practically never diagnosed in living swine, because other, better-known diseases show similar signs.

HOW TRICHINOSIS SPREADS . . .

Trichinosis occurs when warm-blooded mammals eat raw or insufficiently cooked flesh that contains trichinae. The most common source of human trichinosis is pork, although outbreaks have been traced to the meat of wild boar, and bear and walrus meat, among others.

Pigs commonly get trichinosis by eating infected meat scraps in raw garbage (or garbage which has not been properly cooked), by eating the carcasses of infected wildlife, or by eating infected offal. Pigs may also get trichinosis if they eat feces passed by other pigs (or other animals) containing trichinae, but this is not a common method of spread.

The importance of wildlife as a reservoir of trichinae is not known, since there are no accurate incidence figures. However, trichinae have been found in a number of different animals, including rats, mice, dogs, cats, foxes, raccoons, skunks, squirrels, bears, and wolves. Trichinae have also been found in wild boars, whales, walrus, seals, and polar bears.

The chain of infection is perpetuated in nature by carnivorous animals feeding on each other, and by cannibalism (in the case of rats, for instance). Swine enter this chain when they are allowed to eat the carcasses of wild animals that are infected with trichinae. In the past, rats have been accused of being an important reservoir of infection for swine, but current information indicates that this method of spread may have been overemphasized. Nevertheless, strict rodent control would eliminate a possible source of infection for swine.

Much information still remains to be gathered to determine the role of wildlife and other possible source of infection in perpetuating the disease in swine.

THE HISTORY OF TRICHINOSIS . . .

In the early 1800's several human anatomists referred to minute, calcified particles found in the muscles of man during anatomical dissections. However, it remained for James Paget, a 21-year old medical student at St. Bartholomew's Hospital in London, to first identify and describe the parasite.

On February 2, 1835, Paget observed certain little specks in the muscles of a 50-year old Italian man who had died of tuberculosis. The first-year student's curiosity led him to borrow a microscope from Robert Brown, botanist at the British Museum, and under its lens he found that each of these specks consisted of a minute, coiled worm encased in a cyst. Paget turned his material over to his professor, Sir Richard Owen, who presented a paper on the subject later that month in which he named the parasite.

A Philadelphia physician, Joseph Leidy, became the first person to observe the encysted trichinae in pork. This occurred in October 1846. Twenty years later, he recalled the circumstances of this observation. While eating a slice of pork, he noticed some minute specks which reminded him of the trichinae spots he had seen in the muscles of a human subject only a few days previously. He saved the rest of the ham slice, and later, on examining it under the microscope, found it to be full of Trichinella spiralis. However, the parasites were all dead from the heat of the cooking. From this, Dr. Leidy correctly deduced that there was no danger of infection if meat was thoroughly cooked.

Two German scientists--Rudolf Leuckart, an outstanding zoologist and parasitologist, and Rudolph Virchow, the father of modern

pathology--conducted animal experiments during the 1850's demonstrating the development and animal-to-animal transmission of trichinae. But at this point, most medical workers regarded trichinae as merely zoological and medical curiosities--as fairly harmless "guests" of man.

It was not until early in 1860 that trichinae were exposed as pathogenic agents able to produce severe illness and death. In January of that year, Friedrich A. von Zenker, a physician in Dresden, Germany, studied the case of a 20-year-old servant girl who entered the municipal hospital 5 weeks after becoming sick at Christmastime. She died 2 weeks later, supposedly of typhoid fever. However, the course of her illness was not characteristic of typhoid. Zenker carefully recorded all of the now generally recognized symptoms of trichinosis.

Zenker was familiar with trichinae, but there is no evidence that he suspected these parasites as a cause of the girl's death until he was in the midst of an autopsy. He then discovered, on microscopic examination of the muscles of her arm, "dozens of trichinae, lying free in the muscle, either coiled or extended and exhibiting the plainest signs of life." Later Zenker also found sexually mature worms in the girl's intestines.

It is to Zenker's credit that he did not stop with this remarkable discovery. Instead, he went on to make an equally brilliant record as an epidemiologist by tracing, step by step, the circumstances that led to the servant girl's illness and death. In his investigation, he found that her illness had been shared by others, for several persons in the same household had become sick but had recovered.

Zenker visited this household and, from the girl's employer, found that she was in the habit of testing and nibbling all the food she prepared. Apparently she had eaten raw sausage from the meat of a pig killed for the Christmas holidays. Four days later she became sick. The victim's employer and his wife also became ill with similar, but less severe, symptoms. The butcher, too, had eaten some of the pork raw--as was customary among butchers in Germany--and he developed a rather severe case of trichinosis, which was diagnosed as gout.

Fortunately, some of the sausage and a ham were still available. Zenker examined this meat under a microscope and found that it, too, was heavily infected.

The Dresden physician sent portions of the muscles of the young woman to Virchow and Leuckart, which led to further investigations. It was not long before these scientists demonstrated the complete cycle of development of this parasite.

The news of Zenker's discovery spread rapidly. Once the disease was recognized, there were numerous reports from different towns of quite large outbreaks of human trichinosis. This knowledge, quite naturally, caused great public uneasiness and alarm. Two epidemics in the province of Saxony, in particular, exerted a profound influence on the medical and public health authorities of Germany.

The first was in 1863, in Hettstadt, a town of about 4,000 people, where 158 persons contracted trichinosis and 27 of them died. Two years later, in 1865, a second major epidemic occurred in Hedersleben--a town half that size. There, 337 persons fell ill after eating raw or insufficiently cooked pork, and 101 died. During the 20 years from 1860 to 1880, a total of 8,491 cases of trichinosis were registered, with a mortality rate of around 6 percent.

The first approach to the problem was the thorough cooking of all pork. This is perhaps the simplest method of preventing trichinosis--and one of the most effective. Public education campaigns urging this measure were

attempted in Germany and other areas. However, they failed to overcome the fondness of Germans and Middle Europeans, generally, for raw pork--especially sausage and raw spiced ham.

So other methods of prevention were considered. As early as 1863, the microscopic examination of pork for trichinae was practiced in some parts of Germany. Virchow advocated governmental inspection of pork for trichinae by means of the trichinoscope. The inspection consists of compressing a thin slice of meat between two plates of glass and examining the suspect tissue with a magnifying lens or the lower power of a microscope.

In 1866, legislation calling for the trichinoscopic examination of all hogs slaughtered for food was adopted in many parts of Germany. By 1877, obligatory inspection of pork was begun in Prussia--the leading German State at that time--and other States of North Germany as well as the larger towns of South Germany soon followed.

At this point American swine had already gained the reputation of being heavily infected with trichinae. Around 1890 a French veterinarian, after stating the incidence of trichinae in various European countries, wrote: "These figures are greatly exceeded, however, by those of the pigs sent to Europe from the United States of America in such immense numbers, chiefly from the markets of Cincinnati and Chicago; this is demonstrated by the examinations made in different parts of Europe, and even in America."

As indicated by this statement, the United States had developed a thriving pork export market in Europe by the latter part of the 19th century. Starting in 1872, exports of ham and bacon, in particular, jumped sharply, and within a decade were up to 15 times their previous levels. However, fears of trichinae-infected pork soon put a damper on that market.

In 1879 an ordinance was passed by the Italian government forbidding the importation of swine or pork products from the United States. Similar laws prohibiting the importation of American pork were soon introduced in Portugal, Norway, Austria, and Hungary. In 1880, Bismarck signed a decree which prohibited the importation into Germany of American pork sausage and chopped meat and, in 1883, a decree excluding all American pork. In February 1881, France prohibited the importation of all American salted pork (although this interdiction was applied only intermittently during the next decade).

As a result of these actions, bacon and ham exports from the United States dropped sharply--to about 60 percent of their previous level. In 1880, the year before the prohibitions went into effect, the United States sold 70 million pounds of pork to France and 43 million pounds to Germany. Exports to these countries fell to practically nothing. In the 10 years following 1881 American pork was shut out of nearly every market in continental Europe.

In 1883, President Arthur appointed D. E. Salmon, Chief of the Bureau of Animal Industry, to head a commission to investigate the situation. The commission reported first that infection wasn't nearly as high as alleged. Then they presented evidence to show that even if there was some infection, practically all the trichinae were destroyed by the salting process and the length of the trans-Atlantic voyage. Finally, they accused the Germans of incompetent inspections and pointed out that no German outbreaks of trichinosis could be traced to American pork.

Thus, despite the protests, the markets remained closed. So Americans took action.

In August 1890, the Congress of the United States passed a law providing for the inspection of meats for exportation. However, this referred

primarily to the way in which they were packed and their condition at the time of shipment--rather than to the health of the animals at slaughter--and this did not satisfy the foreign requirements.

So on March 3, 1891, Congress passed a much broader meat inspection act which provided for the microscopic examination--to show freedom from trichinae--of all slaughtered pork intended for export. Foreign representatives watched the work carried out under this law very carefully. In September 1891 the German decree of 1883 was repealed and American pork was permitted to enter under certificate. The German action was followed shortly by the removal of a similar prohibition by Denmark and later by Italy, France, and Austria.

However, the lost market was not easy to regain--for a number of reasons. First, the ban had placed a "stigma" on American pork that was hard to erase. Second, trade arrangements that had been disrupted were slow in being set up again--our brands of meat were no longer familiar, commercial connections had been severed, and requirements for cuts and cures had changed. Third, the organization of a force of trained and equipped inspectors to examine the pork for trichinae could not be established overnight.

Nevertheless, some 38 million pounds of pork were microscopically examined the first year, 22 million pounds of which went to countries requiring inspection (by 1893, Germany and France were the only European countries retaining this requirement). This amount of inspected pork for export grew until it reached a high of 120 million pounds in 1898.

However, this growth was not without problems. The Yearbook of Agriculture for 1895 notes: "And notwithstanding the agrarian protectionists of Germany, who have instituted by unjust discriminations every possible impediment to the consumption of pork and beef from the United States in the Empire, 26,670,410 pounds of microscopically inspected hams, bacon, and other cured swine flesh were exported directly to that country; while France, which is intermittently discriminating against us, took 9,203,995 pounds of the same products; Denmark, 472,443; Spain, 4,752; and Italy, 3,630."

The German problem was centered around the fact that, although the action of September 1891 allowed American pork to enter the German Empire under certificate, no kingdom or local authority of the Empire was obliged to recognize the certificate as having any sanitary value. Thus, in May 1892, a Prussian circular was issued which called for the reinspection of American pork. Other local and State governments passed regulations requiring reinspection of American pork.

This led to diplomatic difficulties between the two countries. In 1895, the Secretary of Agriculture even went so far as to hint at retaliation. In the Yearbook of Agriculture, Secretary J. Sterling Morton wrote as follows: "Reciprocal certification of the chemical purity of wines exported from those countries to the United States may some time be demanded from the German and French governments as a sanitary shield to American consumers, for certainly American meats are as wholesome as foreign wines." In 1897, the Department sent a special agricultural attache to Berlin. Charles Wardell Stiles spent nearly 2 years there investigating the charges made against American pork.

Undoubtedly there was some basis for the German accusations. In the haste of reestablishing the trade, the requirements were not always fully understood, and some uninspected shipments were made which were not accompanied by certificates. Also, there is some evidence that uninspected pork was packed in boxes marked with the American inspection

stamp and then shipped from Belgium and Holland into Germany.

On the other hand, American records indicate that more than just sanitary reasons were involved in the German actions--that it was a political and economic question as well. During this period Bismarck embarked on a protectionist policy for German agriculture. The Yearbook of Agriculture of 1897 comments as follows: "We now find a serious obstacle . . . in the active hostility . . . toward our agricultural products by the agrarian population of certain European countries where we formerly possessed a profitable market. Yielding to pressure . . . the governments of these countries have in several instances sought to limit importation from the United States by the imposition of unwarranted restrictions."

The special agricultural attaché was more explicit several years later when he bitterly reported: "There appears to be a systematic attack upon American meats carried on by certain German newspapers and individuals. It is repeatedly asserted that our pork is dangerous . . . local regulations of alleged sanitary nature, but of a most exasperating character, are promulgated . . . butcher associations turn into amateur sanitary societies, and after discoursing at length upon the great dangers of 'Yankee' products and the unheard-of frauds practiced by men who are pictured as almost criminal, they incidentally mention that American competition (while furnishing meat to the working classes) is injuring their own trade."

The difficulties were further complicated in 1898 by the discovery of a secret Prussian circular which instructed officials to withhold information from U.S. Consuls on conditions of health and disease in Prussia. In addition, new German fiscal regulations were put into effect some time later which, according to a 1905 report, "operated against our trade last year to the extent that shipments fell from about 15 million pounds in 1903 to 5 million pounds in 1904."

Thus, when the Congress of the United States passed a new meat inspection act on June 30, 1906, the provisions for microscopic examination of pork intended for export were omitted, and such inspections were discontinued. In his report for 1907, Secretary of Agriculture James "Tama Jim" Wilson said, "Germany, while requiring our certificates of microscopic inspection, was not willing to accept them as conclusive, but reinspected all pork imported from the United States. As the inspection seemed to be of little or no benefit, but of considerable expense, it was stopped."

Trichinoscopic inspection of pork remained important in many countries of Europe, however. Adoption of this system of protection depended, in large part, on the culinary habits of the people.

In France, for instance, trichinosis was rarely seen because people prefer pork well cooked. In contrast, in Germany, where the people are fond of raw or semiraw pork products, trichinosis was widespread--8,491 cases (513 deaths) from 1860 to 1880 and 6,329 cases (318 deaths) from 1881 to 1898. Here trichinoscopic examination of pork was almost a necessity.

A huge number of inspectors were employed to carry on this work. Some worked at this full time, while others such as physicians, druggists and barbers did this inspection work on a part-time basis. The number of inspectors so employed was variously estimated at 18,581 in all of Germany in 1881, and as high as 28,224 in Prussia alone by 1899. It was pointed out that the latter figure was almost as large as the entire army of the United States before the Spanish-American War (28,238 officers and men in 1897).

While the United States' problems with trichinosis at the turn of the century were never really resolved, they did lead to two developments important to today's agriculture. First, they were responsible in part for establishing a Federal meat inspection service. Second, the results of Stiles' work in Berlin in 1897 and 1898 led to the recommendation that agricultural attachés be sent to a number of different countries to represent U.S. agricultural interests.

INCIDENCE OF TRICHINOSIS . . .

Two methods are commonly used to determine if muscle tissue is infected with trichinae: (1) Microscopic examination and (2) the digestion technique.

With microscopic examination, one or more small samples of meat--about 1 gram or less--are examined under the low power of a microscope to see if larvae are present. (A gram of pork is about the size of a lima bean; there are 28.3 grams in 1 ounce.)

With the digestion technique, a much larger amount of meat is used--anywhere from 5 grams to a half pound, although the usual sample size is 45 to 100 grams. This meat is ground, weighed, and then placed in an artificial digestive juice which dissolves the meat and frees any encysted trichinae from their capsules. The larvae are counted, and the degree or intensity of infection is expressed by the number of larvae found per gram of tissue.

Since the sample size is so much larger, trichinae are much more likely to be detected by the digestion method--particularly with light infections. Thus, incidence figures determined by the digestion method run about three to five times higher than figures obtained through microscopic examination. The muscle tissue usually examined in both cases is the hog's diaphragm (the muscular partition separating the chest cavity from that of the abdomen) since this is one of the favorite tissues for trichinae and is readily accessible without mutilating the carcass.

An arbitrary figure of one or more larvae per gram generally has been accepted as the infection level at which some danger to human health might be present. Conversely, pork infected with less than one larva per gram is generally not likely to be harmful to humans.

Incidence in Swine

Garbage-fed swine have long been implicated as the primary source of trichinous pork--and hence, of human trichinosis. Because the feeding of raw garbage to pigs provides a very easy way for the parasite to perpetuate itself, swine fed in this manner have been regarded as a vast reservoir of trichinae.

The cooking of garbage fed to pigs--begun in 1954 as part of the campaign to eradicate VE (vesicular exanthema) and intensified in 1962 as an adjunct to the hog cholera eradication program--has done much to block this avenue of spread.

The latest information shows that 0.5 percent of garbage-fed hogs in the United States are infected with trichinae.

This incidence is based on the results of a statistically designed survey carried out over a 2-year period from July 1964 to July 1966. In this survey, diaphragm samples from nearly 6,000 pigs in randomly selected herds were examined by the digestion technique. Twenty-five hogs were infected. Intensity of infection varied from 0.02 to 18.4 larvae per gram of tissue. Sixty percent of the infected hogs had less than one larvae per gram--40 percent had one or more.

Numerous estimates of the incidence of trichinae in garbage-fed swine have been made in the past

which have shown considerably higher infection rates. A study from 1961 to 1965, for instance, showed 2.6 percent infection, although a downward trend was noted toward the end of this period. During a 22-year span from 1935 to 1957, hogs reportedly fed garbage--mostly raw--showed an infection rate of 5.7 percent (those hogs fed cooked garbage had a much lower incidence). All of these figures were obtained by the digestion technique.

Even though the 1961-65 study showed a much higher incidence than the most recent survey, the intensity of infection was exactly the same in both cases: 60 percent with less than one larvae per gram--40 percent with one or more.

But while attention has been focused primarily on garbage-fed hogs, grain-fed animals are not without infection. Several surveys have been conducted which give some indication of the incidence of infection among grain-fed hogs.

The most recent of these included samples from various areas of the country. Samples collected in the North Central States--where over 80 percent of the Nation's hogs are produced--showed an incidence of infection of 0.067 percent in farm-raised (nongarbage fed) butcher hogs.

Incidence in other sections of the country varied from zero to 1.1 percent, with an overall average of 0.12 percent. Farm-raised breeder hogs showed an incidence of 0.22 percent in the North Central States--the same as the average for the entire country. Intensity of infection was very low--all of the infected butcher hogs had less than one larvae per gram, and four-fifths of the infected breeding animals fell into this category.

Earlier surveys showed a higher incidence. During the period from 1935 to 1957, hogs reportedly fed grain showed an infection rate of 0.79 percent by the digestion technique.

All of these incidence figures, however, are much lower than those found at the turn of the century when microscopic examination was required for all U.S. pork. Of course, in comparing this period with current incidence figures, it must be remembered that the digestion technique is much more accurate than microscopic examination.

Trichinoscopic inspection of export pork was carried on in the United States for a period of 15 years from 1891 to 1906. During the first 2 years of this work, 2.66 percent of over 3 million hogs examined were found to be infected with trichinae. Records are incomplete for the next few years, but during a 9-year period from 1898 to 1906, 1.41 percent of more than 8 million hogs were found to be infected with trichinae, while another 1.17 percent contained trichinaelike bodies.

Today, based on the most recent incidence figures, between 80,000 and 90,000 trichinae-infected hogs are marketed yearly. Most of these are grain-fed hogs--because although infection is higher in garbage-fed hogs, these animals account for only 1.5 percent of all marketings. It should be emphasized that the great majority of these infected hogs do not pose a threat to human health--because of the very low intensity of infection. Perhaps only 6,000 hogs per year are marketed which could cause trichinosis in humans.

The incidence of trichinae in hogs in most of the rest of the world is considerably lower than in the United States--although these incidence figures are based on microscopic examination rather than the digestion technique.

The incidence of trichinae in pork in Prussia was 0.048 percent of 5.7 million hogs in 1878-79--when microscopic inspection was first getting started. This dropped to 0.014 percent of 9.2 million hogs in 1899 and to 0.004 percent of 13.7 million in 1913. The latest figures from Germany show an infection rate of 0.0001 percent--or one hog infected of each million inspected.

In Denmark, compulsory trichinoscopic examination of pork was put into effect in 1910. By 1922, when the practice of feeding garbage to hogs was outlawed, incidence had fallen to 0.76 percent. It declined even more sharply after this, and since 1930, no trichinae-infected pigs have been found in Denmark.

In Sweden, where all pigs slaughtered for human consumption are examined with the microscope for trichinae, the number infected per year out of a slaughter of about 1 million has ranged from a low of 8 to a high of 67 from 1948 to 1959. The incidence in Norway is about as low as that in Sweden.

Incidence of trichinae in pigs in Poland has varied from 0.055 percent during the period from 1923 to 1936 to 0.026 percent in microscopic examination of nearly 68 million hogs from 1947 to 1957.

In many other countries there is no accurate or up-to-date information on the incidence of this parasite in hogs.

Incidence in Humans

Probably many people who have trichinae in their muscles are completely unaware of it--because these "guests," present in such small quantities, do not cause any symptoms, or the symptoms are so slight the patient recovers without the disease being diagnosed.

Yet once infected, a person carries the encysted trichinae for life. Thus, older people--with greater chance for exposure--are more likely to have trichinae in their muscles than younger people.

The incidence of trichinosis in humans in the United States has been falling steadily since 1953. The latest information (1968) indicates that 4 to 5 percent of the population carry trichinae in their bodies.

Various studies carried out during the 1930's and early 1940's showed a much higher incidence--about 16 percent of the human population was apparently infected with the disease at that time. Thus, there has been about a 70-percent reduction of trichinosis during the past 25 years.

The most recent study also shows a definite age-incidence relationship, with younger persons much less likely to be infected. The preponderance of calcified cysts also tends to indicate that only a few of the infections are of recent origin.

This decrease in human incidence is supported by figures from the U.S. Public Health Service on the number of cases of human trichinosis. From 1960 to 1967, there was an average of 180 cases of trichinosis reported yearly. In contrast, the average for the preceding 10 years was 287 cases per year.

TRICHINOSIS AS A PUBLIC HEALTH PROBLEM . . .

The threat of trichinosis to public health depends on (1) the cooking and eating habits of the people involved and (2) the incidence of trichinae in the meat--primarily pork--that they eat.

Thus, in the United States, although the incidence in pigs appears to be relatively high compared to many parts of the world, trichinosis is a relatively rare condition in humans because most Americans eat their pork well cooked.

In contrast, in central and northern Europe, the incidence of trichinae in pigs is relatively low, yet human trichinoisis is a much more serious problem--because of the eating habits of the people. Their fondness for raw or semiraw pork products--such as dry or summer sausage or raw spiced ham--presents a much greater exposure to living trichinae, even though precautions are taken.

Thus, in Poland, for instance, where microscopic examination of pork has

been carried out since the end of World War II, there were 5,322 cases of human trichinosis--with 84 deaths--during the period from 1946 to 1958. Similarly, in Germany, three epidemics in 1949 and 1950 resulted in a total of 502 cases of human trichinosis.

Clinical Diagnosis

Diagnosis of trichinosis in man is often difficult because symptoms usually don't occur until about a week after trichinous meat is eaten. Furthermore, clinical signs of the disease may be absent in the early stages, and those noted in the later stages often simulate other diseases.

The early gastrointestinal symptoms--when they do occur--are often not recognized in the individual patient. Trichinosis in many instances is not suspected until one doctor has examined several patients having a common history of sickness following the eating of raw or insufficiently cooked pork or pork products.

Thus, when trichinosis occurs in epidemic form it is likely to be correctly diagnosed, but isolated infections--especially if they are mild--are often not recognized.

One of the best and earliest signs of trichinosis in man is an eosinophilia (increased numbers of a certain type of white blood cell in the blood). This is especially so with an eosinophilia rising over a period of several days--often to heights of 40 to 80 percent of the white blood cells.

Certain other laboratory and biological tests are available for diagnosis, but their usefulness is limited because they are usually negative early in the course of the disease and may become negative in long-standing infections. These tests include the intradermal test, the complement-fixation test, the precipitin test (including the agar-diffusion test), several flocculation tests such as the bentonite, latex, and charcoal-card tests, and a fluorescent antibody test. All depend on the interaction between an antigen made from the tissues of the parasite (or its metabolic processes) and a specific antibody formed in the tissues of the host as a result of the infection.

Definitive diagnosis of trichinosis must still be based on the actual demonstration of the larvae in muscle tissues.

Treatment

All treatments for trichinosis now used are directed toward relieving the distressing symptoms of the disease. None are presently known which will alter the course of the disease.

Thiabendazole has been reported to reduce intestinal and muscle infections of trichinae in animals under experimental conditions. It has also been used to treat a few cases of human trichinosis, but it has not yet been fully evaluated for this purpose.

PREVENTING TRICHINOSIS IN MAN . . .

In the United States, preventing trichinosis in the human population has been based on an educational campaign stressing the importance of cooking pork thoroughly, coupled with meat inspection procedures which assure that any pork used in products customarily eaten without further cooking has been treated so as to kill all trichinae.

The most effective way to destroy trichinae in meat is to heat it to a minimum temperature of 131° F. throughout. Trichinae may also be destroyed by freezing. Destruction in any case depends on time, temperature, and the size of the piece of meat.

In packing plants operating under Federal meat inspection, pork products that are usually eaten without

cooking are processed to kill trichinae--by cooking, special freezing, or special curing. Those products that are cooked must be heated throughout to 137° F. (6° above the thermal death point of encysted trichinae). Some products cannot be heated to this temperature without harming their marketability. These products can be made from pork which has been held in temperature no higher than -20° for 6 to 12 days, no higher than -10° for 10 to 20 days, or no higher than 5° for 20 to 30 days, the time depending on the size of the pieces of meat in question.

A third alternative under Federal meat inspection regulations--where cooking or freezing would make undesirable changes in the finished product--is to subject the pork (or meat mixtures containing the pork) to the action of salt and drying for relatively long periods.

Microscopic inspection of all pork intended for human consumption has been used as a preventive measure in a number of countries throughout the world. But in the United States, this has been used only in the case of pork intended for export. The motives were economic rather than hygienic, and at no time did American meat inspection authorities seriously consider microscopic examination of pork for trichinae as part of Federal meat inspection procedures.

There are two primary objections to this method of preventing trichinosis--(1) it is costly and (2) it is not foolproof.

It has been estimated that microscopic inspection of pork in the United States would cost at least as much as all Federal meat inspection activities now carried out. Critics of this method of prevention point out further that it might lead to a false sense of security on the part of the public, since not all meat is Federally inspected.

Secondly, microscopic inspection of pork admittedly is not 100 percent perfect, particularly with light infections. Thus in Poland, as recently as 1959, an epidemic of trichinosis--originally diagnosed as a "different" type of flu--involved 378 people. The source of the disease in this case was a sausage called "metka," which is made of 60 percent pork and 40 percent beef and is cured only in cold smoke--thus being essentially a raw meat product.

Thorough investigation revealed that all of the hogs had been submitted to microscopic examination and that the workers had done a conscientious job.

In some countries, however, this method has been successful in practically eradicating trichinosis. For instance, incidence is extremely low in Austria and Italy. In Denmark, compulsory trichinoscopic examination of pork was instituted in 1910, and this, coupled with the prohibition of garbage feeding in 1922, has evidently succeeded in reducing their incidence to zero. Not a single trichinous hog has been found in Denmark since 1930.

One advantage of microscopic examination is that it locates infected hogs and takes them out of market channels--thus preventing possible human infection or reinfection of other swine (through garbage feeding).

Presently, the most effective way for an individual to protect himself against trichinosis is to cook all pork until it is done.

PREVENTING TRICHINOSIS IN PIGS . . .

The best way to keep trichinosis out of swine herds is to eliminate all possible sources of infection.

All garbage fed to pigs--including household scraps--should be cooked. Garbage should be boiled for 30 minutes before it is fed. This not only kills trichinae, but it eliminates other disease organisms such as tuberculosis and hog cholera.

Carcasses of dead animals should not be fed to hogs--they should be buried or sent to a rendering plant.

Strict sanitation and rat control programs will also help eliminate possible sources of infection.

POSSIBILITIES FOR ERADICATING TRICHINOSIS . . .

The pooled sample digestion technique--a new method of detecting trichinosis in hogs slaughtered under commercial meat packing conditions--could help eliminate trichinosis from our swine population.

This new method of detecting the disease was developed by W. J. Zimmermann of Iowa State University. The method is rapid and economical, considering the speed of slaughter and processing in a modern meat packing plant, with a cost estimated at 10 to 15 cents per hog.

Here's how the pooled sample digestion technique works: On the kill floor immediately after slaughter, hog carcasses are divided into lots of 20, with each carcass identified by lot. A 5-gram portion of the diaphragm is removed from each carcass and taken to laboratory facilities within the packing plant for processing. Here the 20 portions are mixed and ground, digested in a pepsin-hydrochloric acid solution for 12 hours, and examined for trichinae. Thus, 20 hogs can be examined with a single test (fig. 2).

The entire process takes about 17 hours. Since hog carcasses are usually held in the cooler for 24 hours after slaughter, the test does not interfere with normal slaughtering operations.

If a single trichina is found, the 20-carcass lot is retained and carcasses are examined individually by the same procedure. Infected carcasses are processed to kill trichinae

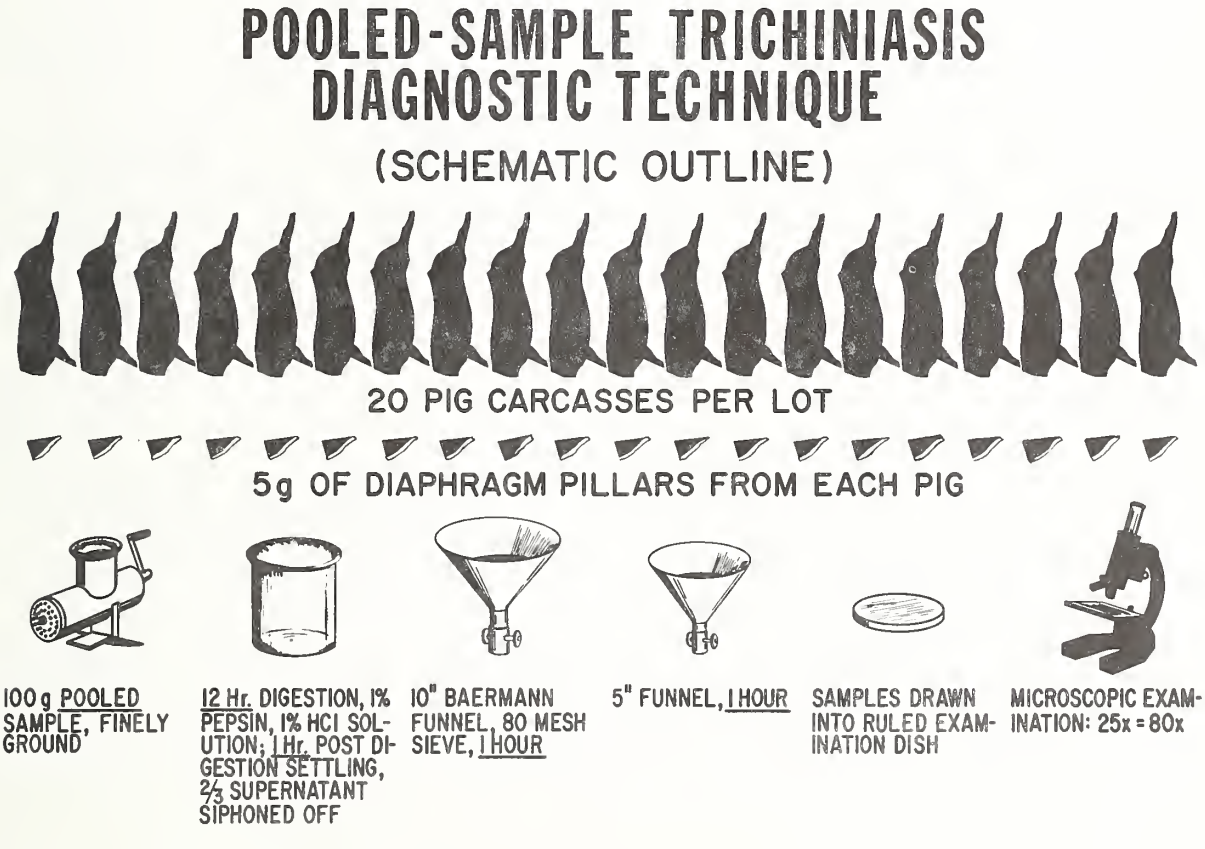

Figure 2.

by prescribed meat inspection methods, while negative carcasses are released for normal processing.

Infected hogs will be traced back to the farm of origin. USDA veterinarians will then try to determine how the hogs became infected and will work with the farmer to eliminate the source of infection.

Early in July 1968, a pilot project to test the effectiveness of the pooled sample digestion technique under commercial meat packing conditions got underway at the Hormel Company meat packing plant in Fort Dodge, Iowa. Cooperating in the pilot project were Hormel, the National Pork Producers Council, the National Livestock and Meat Board, Cudahy Laboratories of Omaha, Nebr., Wilson Laboratories of Chicago, Ill., and units of two USDA agencies--(1) the Animal Health Division and the Animal Disease and Parasite Research Division of the Agricultural Research Service, and (2) the Technical Services Division and Livestock Slaughter Inspection Division of the Consumer and Marketing Service. Livestock Conservation, Inc., an organization representing the entire livestock industry, coordinated industry efforts on the pilot project.

The pilot project ended in February 1969. Over 482,000 hogs were examined for trichinae by the pooled sample digestion technique during nearly 8 months of testing. Only 42 infected animals were found: .009 percent or 1 infected hog out of every 11,500 examined.

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